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ABSTRACT

The message of this article is that there are many types of problems ordinarily requiring advanced techniques or special insight to solve which can now be done as simple programming exercises on inexpensive programmable calculators. Several examples appropriate for the secondary school curriculum are given. These are: (1) evaluating polynomials; (2) graphing functions; (3) solving inequalities and equations; (4) finding limits; (5) evaluating finite and infinite series; (6) computing variable length products; (7) searching for data; and (8) developing proof. Flow charts and programs are presented for one example. (MP)

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"Programmable Calculators Facilitate Simple Solutions To Mathematical Problems"

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Inexpensive programmable calculators can have a significant impact on the pre-college mathematics curriculum. These powerful machines, with their rapid calculating, looping and decision making capabilities frequently reduce the solution of difficult problems requiring advanced techniques or special insights into simple programming exercises. As an example, consider this interesting problem taken from (1, pg 367).

Find three consecutive even integers such that their sum is $\frac{1}{132}$ of their product.

Clearly, an algebraic approach is reasonable and a solution of the problem may be found by finding the roots of either of these equations:

(1) $x^3 + 6x^2 - 388x - 792 = 0$

(2) $x^3 - 400x = 0$.

Equation (1) is obtained by letting the three consecutive even integers be x, x+2 and x+4. To find the roots of the equation requires relatively advanced techniques such as synthetic division.

Equation (2) is obtained by letting the three consective even integers be x-2, x, and x+2. While the roots of the equation can be found by simple factoring, special insight (or perhaps luck?) is necessary in selecting x-2, x, and x+2 as the three consecutive integers.

Another approach to the solution of the problem uses the programmable calculator and avoids the need for the type of advanced technique or special insight noted above.

Consider the flow charts and programs presented in figures 1 and 2. The program in figure 1 is written for the TI 57 and the program in figure 2 is written for the HP 33 E. These machines are chosen as they represent the least expensive models of the two major domestic manufacters and will likely, therefore, have the

greatest impact on the school curriculum.

An important observation about the programs in figures 1 and 2 is in order. The programs are carefully written to illustrate the message of the article not to demonstrate the writing of sophisticated programs. Readers familiar with either the TI 57, the HP 33 E or both will immediately recognize that shorter, more elegant programs can be written to obtain the desired result. However, that is not the point here. This presentation is designed to show how the solution of a difficult problem can be reduced to a simple programming exercise. Hence, the programs are written as one might expect students just becomming familiar with the calculators to write them. In this way, the solution of the problem as given truly is reduced to a simple programming exercise requiring little more than elementary arithmetic and a working knowledge of the basic fundamentals of the calculators computation, looping and decision making features.

While illustrated with but one kind of problem, the message of this article is that there are many types of problems ordinarily requiring advanced techniques or special insight to solve which can now be done as simple programming exercises on inexpensive programmable calculators. Several additional examples appropriate for the school curriculum are given below. Readers are encouraged to search for others and share them. The authors would enjoy corresponding with persons who have discovered interesting problems which can now be solved in the pre-college curriculum with inexpensive hand-held programmables, particularly the TI 57 and HP 33 E (or their predecessors the TI 56 and HP 25). Please direct any correspondence to Professor Spikell at 20 Pinebrook Road, Wayland, MA 01778.

1. Evaluating polynomials

For $x = .4$ what is the value of $5x^3 + 3x^2 - 2x + 3$?

2. Graphing functions

What is the nature of $y = \frac{x(x+2)}{x-3}$

for $-2 < x < -1$?

3. Solving inequalities

For what values of x is $\frac{x^2-3x}{x}$ positive?

4. Solving equations

Find the real roots, if any, of $x^4-5x^3+4=0$.

5. Finding limits

What is $\lim_{x \to 0} \frac{x^2+2x}{x}$?

6. Evaluating infinite series

What is $\sum_{n=1}^{\infty} \frac{1}{3^n}$?

7. Calculating finits series

What is $\sum_{k=1}^{10} k^3$?

8. Computing variable length products

What is the value of $\binom{n}{r} = \frac{n(n-1)\ldots(n-r+1)}{r(r-1)\ldots(1)}$ for n = 10

and r=4?

9. Searching for Data

Find all integer solutions to the system

$a^2 + b^2 = c^2$

$a + b + c = 360$

$a + b > c$

10. Developing proofs

Notice that 153 equals the sum of the cubes of its digits --

$1^3 + 5^3 + 3^3 = 153$

Find all integers with this property and prove that the number of them is finite.

References

1. Brousseau, Brother Alfred. Saint Mary's College Mathematics Contest Problems (Palo Alto, CA: Creative Publications, Inc., 1972).
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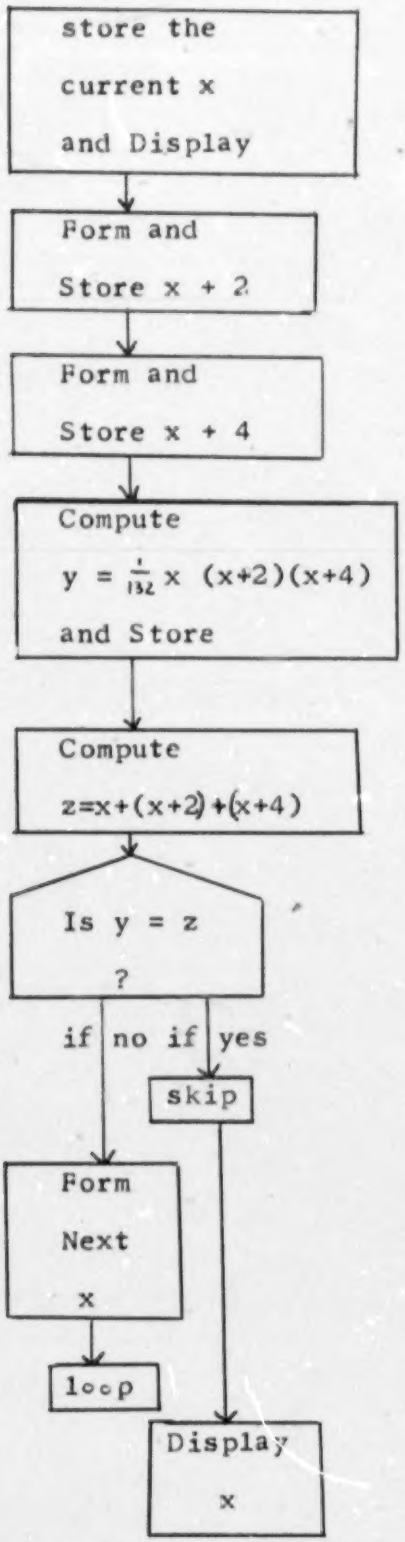
3. ------. "Because of Programmable Calculators, Why Avoid These Programs Any longer," (submitted, January, 1979).
4. ------. "Generally, How Do You Solve Equations?" Mathematics Teacher (to appear).
5. ------. "The Role of Programmable Calculators and Computers in Mathematical Proofs," Mathematics Teacher 71 (December, 1978):745-750.

Flow Chart Program TI 57



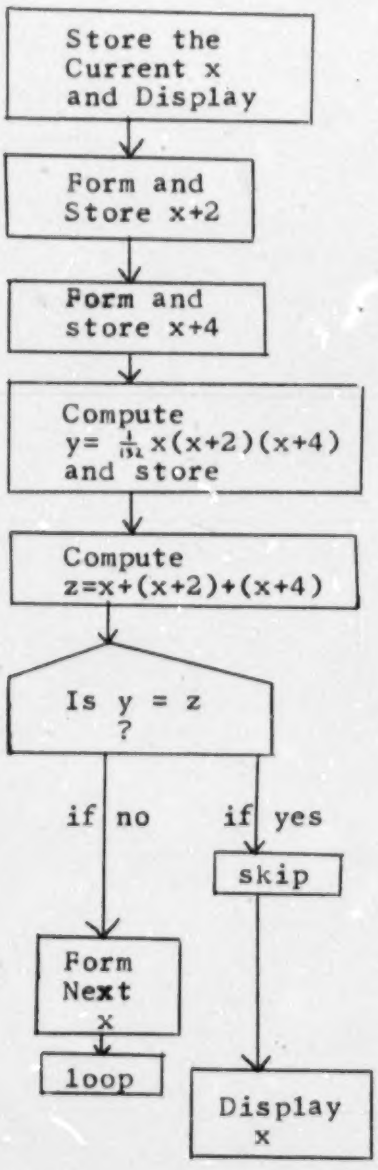

```
00
 STO 1
 2nd Pause

02
 +   STO 2
 2
 =

06
 +   STO 3
 2
 =

10
 RCL  1   RCL 3  3
  x       =      2
 RCL  2   ÷      =
  x       1      STO 4

22
 RCL 1    +
 +        RCL 3
 RCL 2    =

28
 STO 7
                 2nd x=t
 RCL 4

31
 GTO 1

32
 RCL 1    1
  +       =

36
 RST
37
 2nd Lbl 1
  RCL 1
   R/S
```

Memory usage: R_1=x, R_2=x+2, R_3=x+4, R_4=y, R_7=z

Initialize: INV 2nd C.t, RST, enter 1, R/S

Figure 1

Flow Chart Program HP 33E




```
00 (R/S)
01
  STO 1
  f PAUSE
03
  ↑                STO 2
  2
  +
07
  ↑                STO 3
  2
  +
11
  RCL 1            RCL 3   3   STO 4
  RCL 2            x       2
  x                1       ÷
21
  RCL 1            RCL 3
  RCL 2            +
  +
26
  RCL 4
  f x=y
28
  GTO 33
29
  RCL 1
  1
  +
32
  GTO 01
33
  RCL 1
  R/S
```

Memory Usage: R_1=x, R_2=x+2, R_3 = x+4, R_4 = y
Initialize: f PRGM, f REG, f STK, enter 1, R/S

Figure 2